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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI HEADWATERS BASIN
MUSSIGBROD LAKE DAM
BEAVERHEAD COUNTY, MONTANA
MT-184

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the State of Montana Department of Natural Resources and Conservation, Mussigbrod Lake Dam was inspected by Hoskins-Western-Sonderegger, Inc., on 19 September 1979, under the authority of Public Law 92-367. Mussigbrod Lake Dam is located in Beaverhead County, Montana, approximately 15 miles northwest of Wisdom.

This report was compiled from information obtained during an on-site inspection, a review of operation records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

Mussigbrod Lake is operated under a special-use permit from the U.S. Forest Service and is intended to be used for irrigation storage and, secondarily, for recreation. The project consists of a natural lake and an embankment to raise the lake elevation for irrigation storage. The reservoir has a drainage area of approximately 14.7 square miles, surface area of approximately 215 acres at the spillway crest elevation of 6491.0 feet and storage at the minimum dam crest of approximately 3350 acre-feet.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 17-foot-high Mussigbrod Lake Dam (MT-184) is classified as intermediate in size and as having a significant (Category II) downstream hazard potential, due to the presence of approximately 2 inhabitable structures and 1 campground below the dam.

Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of 50% to 100% of the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonable possible in the region. Since several campsites in the campground immediately downstream from the dam could be flooded by a dam breach, we feel that the project should be capable of handling the full PMF.

During the dam safety analysis, an estimated PMF was developed for the drainage basin, resulting from a 24-hour storm. The resulting PMF has a volume of approximately 11,090 acre-feet. The reservoir level at the beginning of the 24-hour storm was assumed to be at the spillway crest elevation. Reservoir routings of the estimated 24-hour PMF indicate that the project will handle approximately 24% of the PMF volume before overtopping if the low-level outlet is closed or approximately 25% of the PMF volume before overtopping if the low-level outlet is fully open. The

dam is constructed of materials that would rapidly erode and fail when overtopped by flood waters. Such failure could endanger the lives of several people and cause considerable property damage.

On the basis of the field inspection and the study of hydrologic and operational data, Mussigbrod Lake Dam does not conform to inspection guidelines with respect to discharge and/or storage capacity to safely handle the recommended SDF.

No evidence of seepage was found either on the downstream face of the embankment or below the downstream toe. However, the location of the phreatic surface could not be determined, because the embankment has no piezometers to measure water levels. There is no internal drainage system, but there is a concrete core wall which appears to be effective. Conditions described in this report suggest that the dam probably conforms to the criteria for embankment stability in the recommended guidelines (Ref. 1); however, insufficient information is available to adequately evalute stability.

PRINCIPAL RECOMMENDATIONS

Due to the availability of storage between the normal pool and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam overtopping. Establish a formal maintenance plan.

Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate. Evaluate embankment stability and place a record of this evaluation on file. Modify the project as required.

Prior to performing engineering studies and/or remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal Identification Number	MT-184
Owner/Operator	Buck Ranches
Purpose	Irrigation storage and recreation
Location	Sec. 32, T1N, R16W Beaverhead County
Watershed	Mussigbrod Creek
Downstream Hazard Potential	Significant (Category 2)
Size Classification	Intermediate
USGS Quadrangle	Mussigbrod Lake, Montana Bender Point, Montana

2. RESERVOIR

Surface Area at Normal Pool (Spillway Crest)	215 acres
Normal Storage (Spillway Crest)	1640 acre-feet
Total Storage (Minimum Dam Crest)	3350 acre-feet
Surcharge Storage	1710 acre-feet
Drainage Area	14.7 square miles
Reservoir Water Surface Elev. (9/19/79)	6482.5 feet (NGVD)

3. SPILLWAY

Type	Uncontrolled earth and rock channel with concrete box inlet drop structure
Crest Elevation	6491.0 feet (NGVD)
Crest Width	35 feet
Spillway Capacity (Minimum Dam Crest)	2370 cfs

4. OUTLET WORKS

Type	Controlled reinforced concrete pipe with trash rack at upstream end
Controls	Sloping-stem slide gate with enclosed manual control from dam crest
Size	30-inch-diameter
Length	89 feet
Inlet Invert	6481.8 feet (NGVD)
Outlet Invert	6480.5 feet (NGVD)
Normal Tailwater	Unknown
Discharge Capacity (Minimum Dam Crest)	95 cfs

5. DAM

Type	Earthfill
Maximum Height (Hydraulic)	17 feet
Crest Length	500 feet
Minimum Crest Elevation	6497.6 feet (NGVD)
Crest Width	10 feet
Upstream Slope	1(V) on 2.9(H)
Downstream Slope	1(V) on 2.1(H)

Note: All elevations referenced from spillway crest elevation of 6491.0 feet shown on SCS plans for Mussigbrod Dam Rehabilitation. Datum is National Geodetic Vertical Datum (NGVD).

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Mussigbrod Lake Dam owned by Buck Ranches of Wisdom, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any emergency measures and/or additional studies, investigations, and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed

to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act and neither any action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and interviews with the owners and/or individuals familiar with the dam facilities. SCS design drawings from a dam reconstruction project completed in July 1969 were made available for review. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers; and
Art Taylor, Civil Engineer, State of Montana, Department of Natural Resources and Conservation.

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Mike McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of the Soil Conservation Service, the Montana Department of Natural Resources and Conservation, the Forest Service, and the owner (Buck Ranches). Written comments are included in the Appendix of this report. The owner did not comment.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Mussigbrod Lake is a natural glacial lake whose natural storage was increased by construction of a dam. Mussigbrod Lake Dam (MT-184), owned and operated by Buck Ranches, is located on Mussigbrod Creek in Section 32, T1N, R16W, Beaverhead County, Montana, approximately 15 miles northwest of Wisdom, Montana. The reservoir has a surface area of approximately 215 acres and storage of approximately 1640 acre-feet at the spillway crest elevation of 6491.0 feet. The natural storage of the lake is unknown. The local drainage area is approximately 14.7 square miles.

The project is operated under a special-use permit from the U.S. Forest Service. An uncontrolled, earth and rock channel spillway is located approximately 425 feet south of the right dam abutment. At the crest of the spillway is a reinforced concrete, box inlet, drop structure, 35 feet wide and 5.5 feet deep. The dam has a 30-inch-diameter, reinforced concrete, low-level outlet conduit, with an inclined, manually controlled slide gate, located approximately 130 feet southwest of the left dam abutment.

Mussigbrod Lake Dam is approximately 17 feet high and impounds approximately 3350 acre-feet at the minimum dam crest elevation of 6497.6 feet. Based on visual reconnaissance and engineering judgment, approximately 1 campground and 2 residences could be affected by a sudden breach of the dam. Mussigbrod lake Dam, therefore, is classified as intermediate in size and has a significant (Category II) downstream hazard potential classification (Ref. 1).

1.2.2 Regional Geology

Mussigbrod Lake lies on the east side of the Continental Divide on the eastern margin of the fault-blocked Bitterroot Range north of the Beaverhead Mountains.

The northern Rocky Mountain region, prior to Late Cretaceous time, was essentially a flat plain partially flooded by shallow seas. At the end of the Mesozoic Era, of which the Cretaceous is the last geologic epoch, this entire area became geologically active. Three things exemplify this activity: (1) Cretaceous uplift; (2) Late Cretaceous thrust faulting; and (3) Late Cretaceous-Tertiary intrusive activity, i.e., the Idaho Batholith.

The regional uplifting of the continental crust brought the earth up in several north-south trending blocks (the Bitterroot Mountains). The west sides of these faulted blocks are higher in elevation and have characteristically abrupt scarps, while the east sides of the blocks have long, gentle slopes.

The Bitterroot Mountains are at the western edge of Montana and are composed of a complex suite of igneous rocks, the Idaho Batholith, which has intruded into and uplifted the much older sedimentary and metamorphic rocks of the area.

The uplifted land immediately became subjected to erosion and, as the sediments were transported downslope, they filled the intermountain valleys, such as the Big Hole valley, with debris ranging from muds and sands to gravels and cobbles. These valley-fill sediments attain a depth of several thousand feet in the axis of the mountain valleys.

Pleistocene alpine glaciation of Wisconsin Age (12,000 years before present) sculptured typical alpine glacial features including cirques, headwalls, and troughs in the upper elevations of the Bitterroot Mountains. In lower elevations, glacial deposits of terrace gravel, stream bed alluvium, landslide rubble, and glacial drift occur.

1.2.3 Seismicity

Mussigbrod Lake lies intermediate between Seismic Zones 2 and 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of a potential for moderate to major damage and is based on the known distribution of damaging earthquakes in the region.

The "Preliminary Map of Young Faults in the United States," and the preliminary maps showing known and suspected active faults in Idaho and Montana, all by the U.S. Geological Survey (Ref. 2, 3, and 4), indicate no tectonic activity at or near Mussigbrod Lake. The Bitterroot Fault, a north-trending fault, is 25 miles west-northwest of the lake and has moved in historic time. The other areas of major faulting occur 35 miles north-northeast, 45 miles east, and 65 miles south of Mussigbrod Lake.

Local earthquakes significant enough to be reported in References 5 and 6 occur in 3 epicentral areas. One of these is to the northeast, along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, while another is to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Of these two epicentral areas the one is 130 to 150 miles to the southeast and the other is 130 miles to the north-northeast of the project area. A third area of significant earthquake activity is in central Idaho 100 miles to the southwest of Mussigbrod Lake. In that vicinity on January 27, 1963, an earthquake of intensity VI (Modified Mercalli) occurred, and several earthquakes with intensities of V have occurred since the early 1900's. Two earthquakes of significant intensity that occurred in the tri-state region southeast of the project site were the Hebgen Lake, Montana, earthquake (8 August 1959), that had an intensity of X, and another earthquake southeast of Dillon, Montana, and southeast of the project area (23 November 1947), that had an intensity of VIII. The three largest reported earthquakes in the epicentral area northeast of Mussigbrod Lake have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935).

In the vicinity of the project, the closest reported earthquake occurred at Curlew Mine, 14 miles north of Hamilton and 42 miles northwest of Mussigbrod Lake. The intensity and date of this earthquake is not known.

Mussigbrod lake lies in an area of moderate to major potential for a damaging earthquake. Because this dam was probably designed and constructed without consideration of the effects of earthquakes on stability, special attention should be given to earthquake design during any stability analysis.

1.2.4 Site Geology

The lake is contained in a level glacial trough valley and retained by moraines. A previously developed flood plain and thick soil mantle (regolith) covers the site. The valley contains deep organic soils and moderately deep, poorly drained loams and silt loams. Substrata consists of reworked fine glacial outwash. Willows characterize the tree growth in the bottomlands.

The southwest valley wall is characterized as a strongly sloping (25% to 45%) to steep, glacial trough wall with thick till deposits. The sediments are frost-churned and overlie a thick rock mantle. The soils could be described as moderately deep to deep, well drained, cobbly loams and sandy loams with clay loam subsoils. Bedrock is basically igneous rocks.

The northwest valley slope is steep to very steep with scoured glacial trough walls and thin till deposits. The slope is dissected, with a thin to moderately thick rock mantle. Soils are shallow, well drained, gravelly sandy loams, loamy sands and loams.

The drainage area varies from strongly scoured cirque basins, talus slopes, rock glaciers, and rock land to nearly level glacial trough valley bottoms covered by glacial drift. Other less dominant features are sloping, slightly convex, moderately frost-churned ridgetops with thick regolith and well drained, angular, gravelly, loamy sands; very steep (60% to 80%) cirque headwalls and associated rock glaciers; and undulating to gently rolling, thin, lateral glacial moraines. These moraines are mantled by deep, cobbly, poorly drained sandy loams and are characterized by bogs and kettles. These features are characteristic of an older, reworked, glacial valley.

1.2.5 Design and Construction History

The present dam structure at Mussigbrod Lake, which was completed in November 1969, replaced an earlier constructed dam which was deficient. The new construction included the reconstruction and connection of two earth fill dam embankments, the construction of a 30-inch-diameter reinforced concrete pipe irrigation outlet with a steel slide gate, the construction of a reinforced concrete spillway structure, and repair of the existing concrete core wall. The design of the project was accomplished by the Soil Conservation Service according to criteria set by the SCS and the Forest Service. Design reports indicate that the dam was designed to pass the 100-year flood with 3 feet of freeboard. Construction was done by the owner under the supervision of the SCS and Forest Service. Since the new construction, inspection reports indicate a history of regular maintenance with no significant problems.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway is located approximately 425 feet south of the right dam abutment and discharges into Mussigbrod Creek. The spillway is an uncontrolled, earth and rock channel with a reinforced concrete, box inlet, drop structure at its crest. This structure is 35 feet wide with a 5.5-foot drop. The weir projects 5 feet into the approach channel, resulting in a weir length of 45 feet (See Plate 11 and Photos 9 and 10). The earth and rock approach and exit channels have an irregular surface covered with large boulders and some debris and brush. Approximately 40 feet upstream of the crest structure is a log boom. When water levels are sufficiently high enough to reach the spillway crest, head losses caused by flows through the 40-foot-long approach channel have a negligible effect on discharges. The slope of the approach channel varies from 0% to 5%. The exit channel slope varies from 1% to 3%. The spillway channel and crest structure can be seen in Photos 7 through 12, and the profile and typical cross sections can be seen on Plate 4, all in this report.

The wingwalls for the crest structure have a top elevation of 6496.0 feet, which is approximately 1.6 feet below the minimum crest elevation of the dam. Overflow of these wingwalls would occur, therefore, prior to overtopping of the dam. There is also a natural overflow area approximately 85 feet left of the center of the crest structure. The low point of this overflow area is approximately 0.7 feet below the minimum crest elevation of the dam.

The spillway channel appears to be in reasonbly good condition with no serious erosion damage. The log boom is also in good operational condition, keeping most of the floating debris out of the spillway channel. The channel on the upstream side of the crest structure is obstructed somewhat by large boulders which, if not removed, will reduce spillway discharge. The concrete crest structure is in good condition, with some surface erosion and small cracks, but with no significant deficiencies.

The discharge rating curve for the spillway was computed using the equation for flow over a weir. The discharge coefficient "C", which ranged from 2.6 to 3.2, was varied according to head and was adjusted for the box inlet drop structure configuration according to guidelines in Reference 7. Submergence of the weir due to tailwater from the exit channel was also taken into consideration. Overflow of the crest structure wingwalls and flow through the natural overflow area were both included in the determination of the spillway discharge capacity. The calculated capacity of the spillway varies from 0 cubic feet per second (cfs) at the minimum crest elevation of 6491.0 feet to 2370 cfs at the minimum dam crest elevation of 6497.6 feet. A complete discharge rating curve for the spillway is shown on Plate 6.

2.1.2 Outlet Works

The irrigation outlet is located approximately 130 feet southwest of the left dam abutment. The outlet conduit consists of 89 feet of 30-inch-diameter reinforced concrete pipe running through the dam. The outlet is controlled by an inclined, manually operated, slide gate, located at the upstream end of the pipe and operated from a control box on the upstream shoulder of the dam crest. At the upstream end of the pipe is a trash rack constructed of reinforced concrete with steel bars for the rack. The invert of the upstream end of the pipe is at an elevation of 6481.8 feet, which is 15.8 feet below the minimum dam crest elevation. The invert of the downstream end of the pipe is at an elevation of 6480.5 feet, which is 17.1 feet below the minimum dam crest elevation. The irrigation outlet works can be seen in Photos 13 through 17 and on Plate 2.

The condition of the irrigation outlet works was found to be generally good, and the concrete box housing the gate control was also in good condition. The concrete trash rack structure showed some cracking and spalling and some surface erosion, generally on the upstream surfaces. Some rusting was evident on the trash rack bars and on the slide gate mechanism. The log boom for the low level inlet was broken. Although the plans (Plate 10) indicate an enlargement from 30-inch to 48-inch conduit, the field investigation found 30-inch-diameter reinforced concrete pipe on both the upstream and downstream ends of the conduit. It is assumed that the original 48-inch pipe was all replaced during reconstruction. The visible portion of the pipe appeared to be in good structural condition. A sag of 3 to 4 inches and a continuous lateral curvature with a maximum misalignment of 3 to 4 inches to the right, looking downstream, were noticed in the interior portions of the conduit. The entire length of the conduit was not inspected. Some erosion was evident in the outlet plunge pool, but did not appear to endanger the dam.

The capacity of the irrigation outlet, assuming the water level to be at the minimum dam crest elevation of 6497.6 feet, was computed to be 95 cfs. This capacity was based on full pipe flow and assuming the control gate to be in the fully-opened position. The complete outlet discharge rating curve can be seen on Plate 7.

2.1.3 Freeboard

The normal pool elevation of Mussigbrod Lake is assumed to be the crest elevation of the spillway, 6491.0 feet. The vertical distance between the normal pool and the minimum dam crest is 6.6 feet.

The effective fetch for wind-generated waves is approximately 0.16 miles. The total wave run-up and wind set-up is approximately 1.5 feet (Ref. 8). Thus, the vertical distance between the normal pool and the minimum dam crest elevation is adequate protection in accordance with the criteria in Reference 9.

Routings indicate that the dam will be overtopped during the probable maximum flood (PMF); therefore, no freeboard exists during the PMF (see Section 3.1.1).

2.2 HYDROLOGY, CLIMATOLOGY AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around Mussigbrod Lake is continental and characterized by a large daily and seasonal temperature range. Extreme variability of wintertime temperatures results from frequent occurrence of chinook winds which follow a Pacific maritime air mass invasion. The summers are characterized by warm days with low humidity and cool nights. Winters are cold and highly variable in severity from year to year and within a given year.

Wisdom, Montana, in Beaverhead County at an elevation of 6058 feet, is the climatological station nearest the project site. Precipitation and climatological data from this station are not applicable to the project because of the 433-foot elevation difference between Mussigbrod Lake and the weather station. The average annual precipitation at Mussigbrod Lake is approximately 25 inches (Ref. 10). Also, the average expected date of first freeze is August 16th, and the average expected date of the last freeze is July 19th (Ref. 11).

The drainage basin above and including Mussigbrod Lake has an area of approximately 14.7 square miles. Other than the main stream (Mussigbrod Creek) upon which Mussigbrod Lake Dam is built, there are no other developed perennial tributaries draining into the lake. Basin elevations range from the spillway crest elevation of 6491.0 feet to approximately 8810 feet at the drainage divide. Basin vegetation consists of moderately thick pine and sparse grasses on rocky soils.

2.2.2 Reservoir Storage and Spillway Discharge

Mussigbrod Lake has a surface area of approximately 215 acres and a storage volume of approximately 1640 acre-feet at the spillway crest elevation of 6491.0 feet. Storage of approximately 1710 acre-feet is available between the spillway crest and the minimum dam crest elevation of 6497.6 feet (see Plate 5). Discharge through the spillway and the natural overflow area with the water surface at the minimum dam crest is approximately 2370 cfs. Discharge through the irrigation outlet under these conditions would result in an additional 95 cfs, with the control gate in the fully-opened position. Complete discharge rating curves for the spillway and the irrigation outlet are shown on Plates 6 and 7, respectively.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is defined as the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A storm, the intensity

of which approached probable maximum precipitation (PMP) intensity, did occur in parts of Montana in June 1964.

A PMP storm of 24-hour duration was applied to the Mussigbrod Lake drainage basin. The 24-hour, 12-hour, 6-hour, and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 12) to be 14.2 inches, 11.9 inches, 9.8 inches, and 5.6 inches, respectively. All 6-hour increments from 0 to 24 hours and the hourly increments of the maximum 6-hour increment were arranged in accordance with criteria in Weather Bureau Hydrometeorological Report No. 43 (Ref. 13).

The PMF was assumed to result from a PMP storm in late spring over frozen ground. Thus, a constant soil loss rate of zero was applied throughout the 24-hour PMP storm, in accordance with Corps of Engineers recommendations. Therefore, the overall configuration of the 24-hour storm is not affected by losses in the soil, and basin rainfall is equal to basin runoff for all storm increments. Direct precipitation onto the surface of the lake was also added in with no losses.

2.2.4 Flood Routing

The level of Mussigbrod Lake at the beginning of the 24-hour storm was assumed to be at the spillway crest elevation of 6491.0 feet, corresponding to assumed normal pool conditions. The total volume of the 24-hour PMF for Mussigbrod Lake is approximately 11,090 acre-feet with a peak inflow rate of approximately 47,700 cfs. Reservoir routings indicate that, with the control gate of the irrigation outlet closed, the lake will handle, through storage and spillway discharge, approximately 24% of the PMF volume before overtopping. With the control gate of the irrigation outlet fully open, the lake will handle approximately 25% of the PMF volume before overtopping.

PMF hydrographs were developed using the SCS dimensionless unit hydrograph. Reservoir routings of the inflow hydrographs were made using the Modified Puls method. The HEC-1 (Dam Safety Version) computer program (Ref. 14) was used for the hydrograph computations and reservoir routings.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankment

The 17-foot-high earth dam is 500 feet long and has a crest width of 10 feet. The upstream slope is generally 1(V) on 2.9(H). The downstream slope is generally 1(V) on 2.1(H). According to Forest Service records, borrow for the embankment was obtained from the area above the left abutment that is now used as a parking lot. The material exposed on the crest of the dam is a silty sand-gravel, with some cobbles and boulders. The material on the downstream slope is similar, only with more large rocks. The embankment material is considered to be highly erodible. The upstream slope is covered with rock riprap, generally ranging in size from 6 inches to 24 inches in diameter, with a few larger pieces. Vegetation is sparse. The upstream face has a few weeds and grasses growing through the riprap,

especially near the top of the slope (see Photos 1, 2, and 3). The crest is essentially bare. The downstream face has about 20% coverage of weeds and grasses (see Photos 4, 5 and 6), most of which are near the toe.

The riprap on the upstream face of the embankment is igneous rock. No evidence was found of a granular bedding or filter course between the riprap and the embankment. No sags or bulges were noted on the upstream or downstream faces.

Drawings show that a concrete core wall is incorporated in the embankment, near the embankment center line (Plate 9). The wall does not reach the crest of the dam.

2.3.2. Foundation Conditions, Seepage, and Drainage

Except for some soft lake sediments found at the upstream toe during reconstruction, the dam is probably founded on silty sand-gravel similar to that used in the embankment itself. This material is considered to be quite pervious. The core wall appears to have been incorporated to limit seepage. Fairly dense, low vegetation at the downstream embankment toe was taken as evidence of slight seepage.

There was nothing to indicate that the dam included any type of drain, nor are there any piezometers installed in the dam.

2.3.3 Stability

Although considerable time and money were used to rebuild the dam and appurtenances between 1967 and 1969, a stability analysis was not performed.

Given the granular nature of the embankment, the relatively flat upstream slope, the apparently effective core wall, and a 10-year history of satisfactory service, it is our judgment that the stability of the embankment may conform to the inspection guidelines (Ref. 1). However, insufficient information is available to adequately evaluate stability.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Mussigbrod Lake and Dam is the responsibility of Buck Ranches, with technical assistance provided by the Forest Service. A formal plan for the operation and maintenance of Mussigbrod Lake and Dam (reconstructed in 1969) was not available at this writing, but records and inspections since 1969 indicate a favorable history of maintenance and upkeep. Operation of the dam is by a special-use permit issued by the U.S. Forest Service.

2.4.2 Dam

Although there is no formal maintenance plan for Mussigbrod Lake Dam, Forest Service inspection reports and site evidence indicate a fairly

high level of maintenance activity. Current maintenance needs consist of the removal of already-collected debris, repair or replacement of the log boom which had protected the low-level outlet, and the painting of rusty steel on the trash rack and slide gate.

2.4.3 Reservoir

As previously mentioned, there is no formal plan for operation and maintenance of Mussigbrod Lake, other than the inferred responsibilities in the special-use permit. It appears that the dam is visited at least twice per year for maintenance purposes. Generally, the lake is allowed to fill in the fall, winter, and part of the spring, and the subsequent storage is discharged for irrigation purposes during the remainder of the year. The lake is a recreational area and is accessible by vehicle during the summer and portions of spring and fall.

Despite the lack of a plan, attention to maintenance has been favorable since the reconstruction of the dam in 1969. The most significant maintenance problem indicated in inspection reports has been the periodic accumulation of floating debris in the lake, along the embankment, and in the spillway channel.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of Mussigbrod Lake and Dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

According to the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), Mussigbrod Lake Dam is classified as intermediate in size with a significant downstream hazard potential rating. The recommended spillway design flood (SDF) for this project is 100% of the probable maximum flood (PMF). The project can control only about 24% of the PMF volume and, therefore, does not conform to inspection guidelines.

3.1.2 Embankment Dam

As noted in Section 2.3, the embankment appears to be in very good condition. There are no indications of instability and only minor evidence of seepage. Vegetative covering is sparse, but there is no sign of erosion.

There are no piezometers installed in the dam. Therefore, the location of the phreatic surface cannot be determined.

Based on experience with similar structures and materials, the main dam may conform to criteria in the inspection guidelines on stability; however, insufficient information is available to adequately evaluate stability.

3.1.3 Spillway

The uncontrolled, earth and rock spillway channel appears to be in reasonably good condition with no serious erosion damage. The log boom is in good operational condition, keeping most of the floating debris out of the spillway channel. The channel is obstructed somewhat by the large boulders on the upstream side of the crest structure and needs periodic clearing. The concrete box inlet drop structure is in good condition, with some surface erosion and small cracks, but no significant deficiencies.

3.1.4 Outlet Works

All visible parts of the irrigation outlet works were found to be in generally good condition; however, the entire length of the conduit was not inspected. The concrete trash rack and inlet structure showed some cracking and spalling and some surface erosion on the upstream surfaces.

Some rusting was evident on the trash rack bars and slide gate mechanism. The log boom for the low-level inlet was broken. The outlet end of the reinforced concrete pipe was in good structural condition; however, a sag of 3 to 4 inches and a continuous lateral curvature with a maximum misalignment of 3 to 4 inches to the right, looking downstream, were noticed in the interior portions of the conduit.

3.1.5 Spillway and Reservoir Capacity

The lake storage capacity and spillway discharge capacity are insufficient to prevent overtopping during the estimated PMF.

3.1.6 Operation and Maintenance

Operation and maintenance are performed by the owner, with technical assistance provided by the Forst Service. There is no formal operation plan for the reservoir. Water from spring runoff is stored in the reservoir and is released from the outlet as needed for irrigation. Consequently, the lake level fluctuates seasonally.

There is no formal maintenance plan for the dam, but the facility has a history of timely maintenance. Current maintenance needs are debris removal, rust removal and painting on the low-level slide gate and the steel bars of the trash rack, and repair of the log boom protecting the low-level inlet.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to the availability of storage between the normal pool elevation and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of the recommendations in this report is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam overtopping.

2. After removing all rust, use a proven rust-resistant paint system to paint all rusted metal on the trash rack and the low-level slide gate.

3. Remove all debris from the vicinity of the embankment and the spillway.

4. Repair the log boom to protect the low-level inlet.

5. Inspect the entire outlet conduit and repair as required.

6. Conduct more-detailed hydraulic and hydrologic routing studies to better determine the downstream hazard and the required spillway capacity. Modify the project as studies indicate.

7. Evaluate embankment stability and place on file a record of this evaluation. Modify the project as required.

8. Coordinate with the U.S. Forst Service to consider the possibility of relocating the campground below the dam and, thereby, reducing the dam's hazard potential classification.

9. Develop and implement a periodic maintenance plan for the dam and appurtenant structures. Because of the remoteness of the project site, the maintenance plan should include frequent condition inspections whenever water is impounded above the natural lake level.

10. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers experienced in the design, construction, operation, and maintenance of earth dams.

Prior to performing engineering studies and/or remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

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7. U.S. Department of Transportation, Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, December 1975.

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11. Caprio, J.M., "Montana: Average Dates of Freeze," Folders No. 81, 82, and 83, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana, March 1965.

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13. U.S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, Washington, D.C., November 1966.

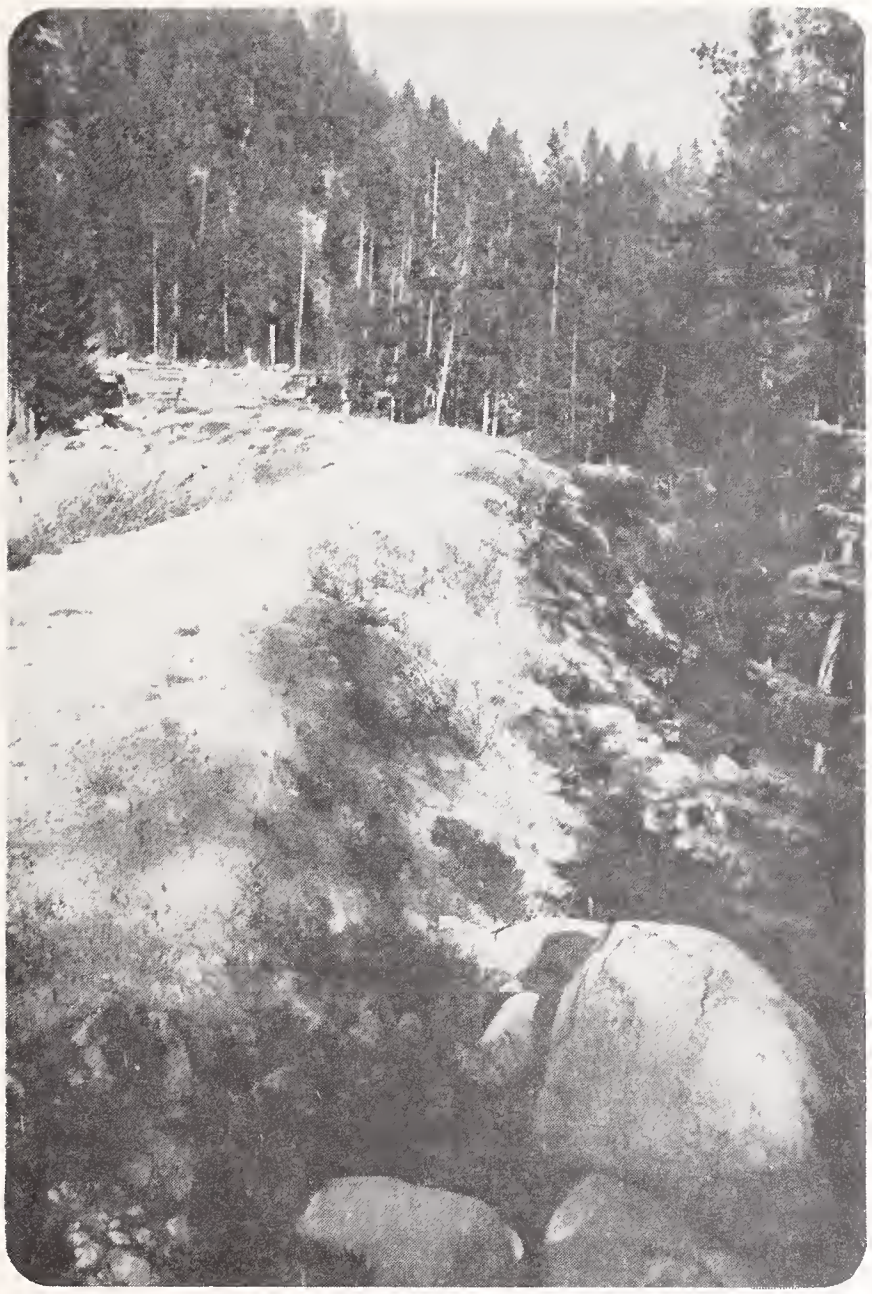
14. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users' Manual for Dam Safety Investigations, Davis, California, September 1978.

(PHOTO 1) Upstream Face from Left Side of Reservoir

(PHOTO 2) Upstream Face from Left Abutment

(PHOTO 3) Upstream Face from Right Abutment

(PHOTO 4) Left Abutment Trough and Downstream Face

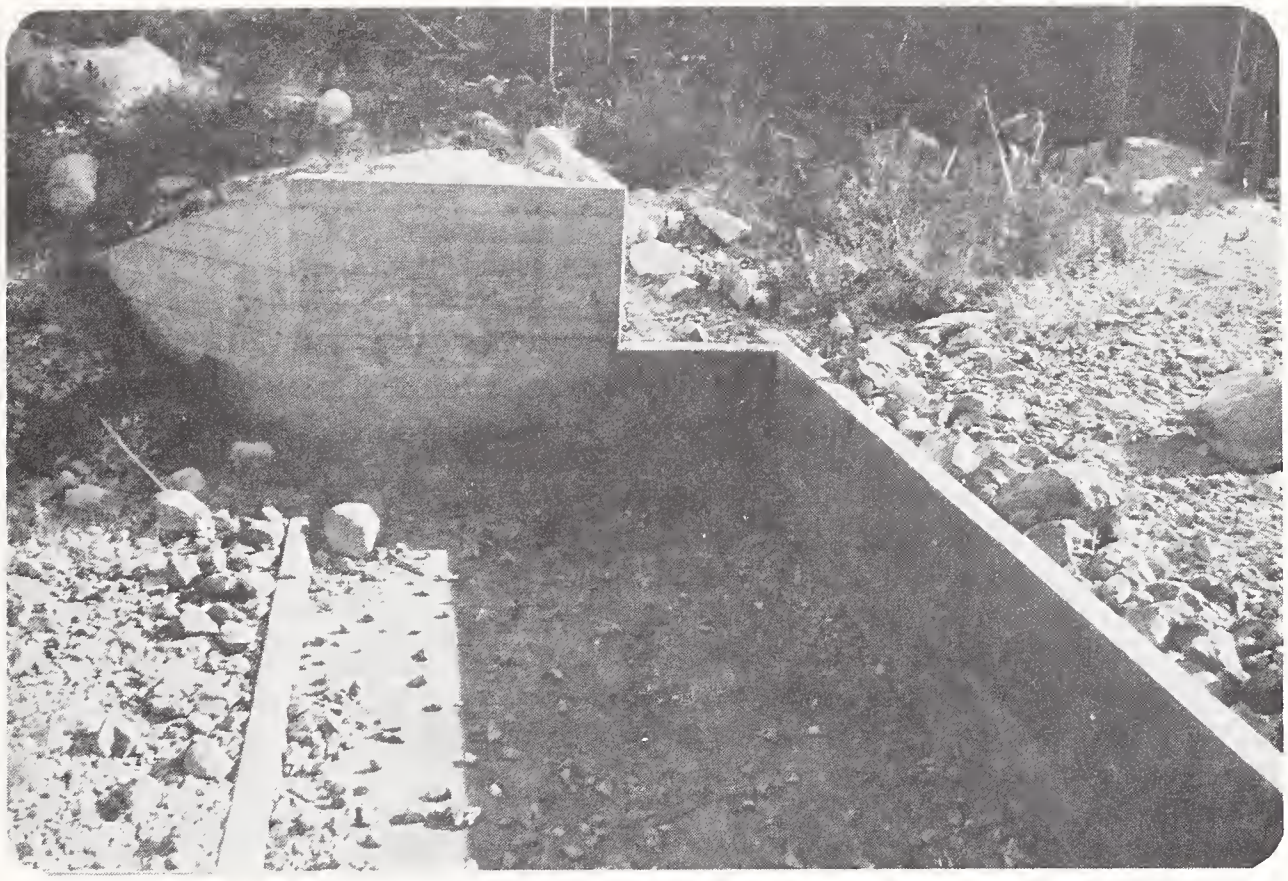


(PHOTO 5) Crest and Left Abutment from Center of Dam

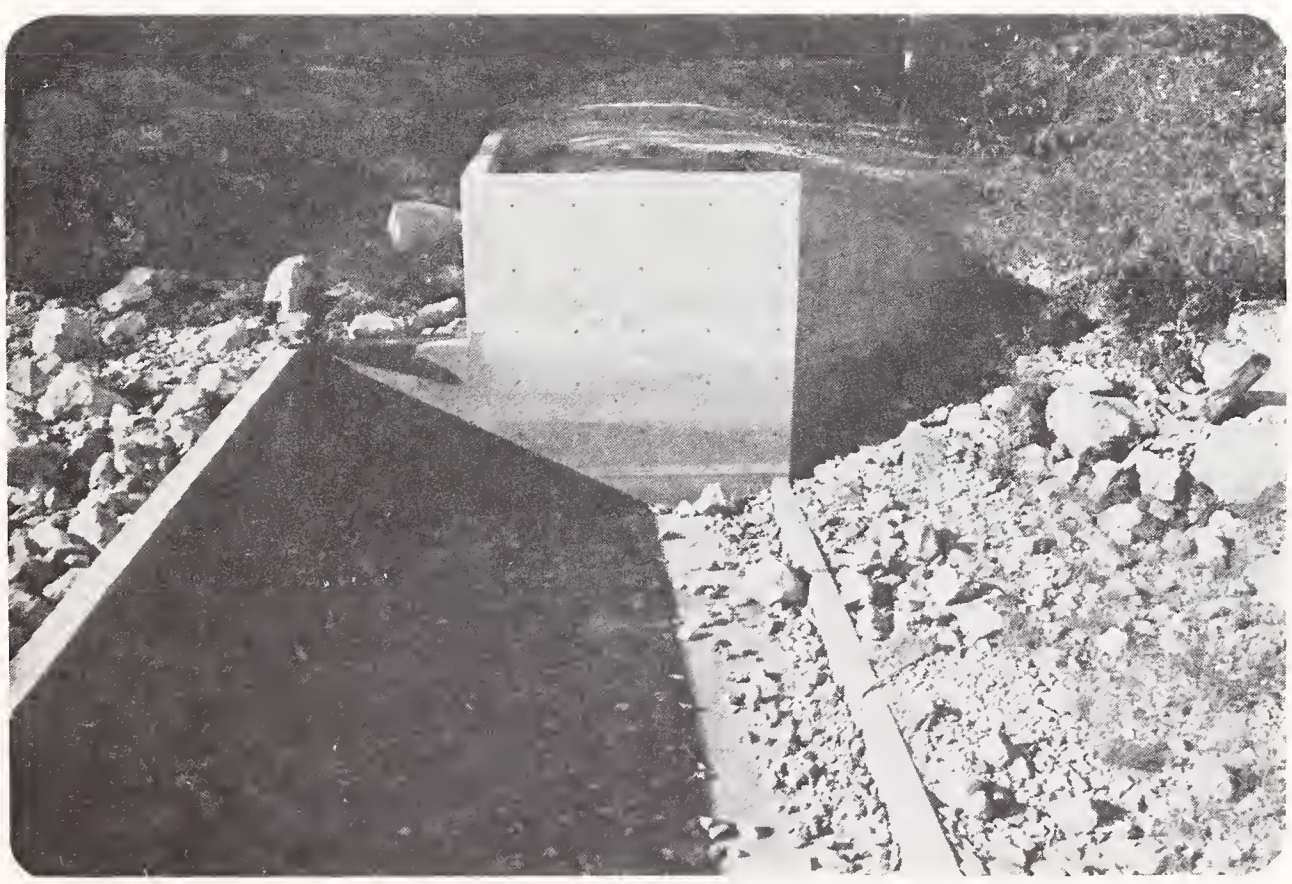
(PHOTO 6) Crest from Right Abutment

(PHOTO 7) Spillway Approach Channel and Log Boom

(PHOTO 8) Spillway Crest from Approach Channel



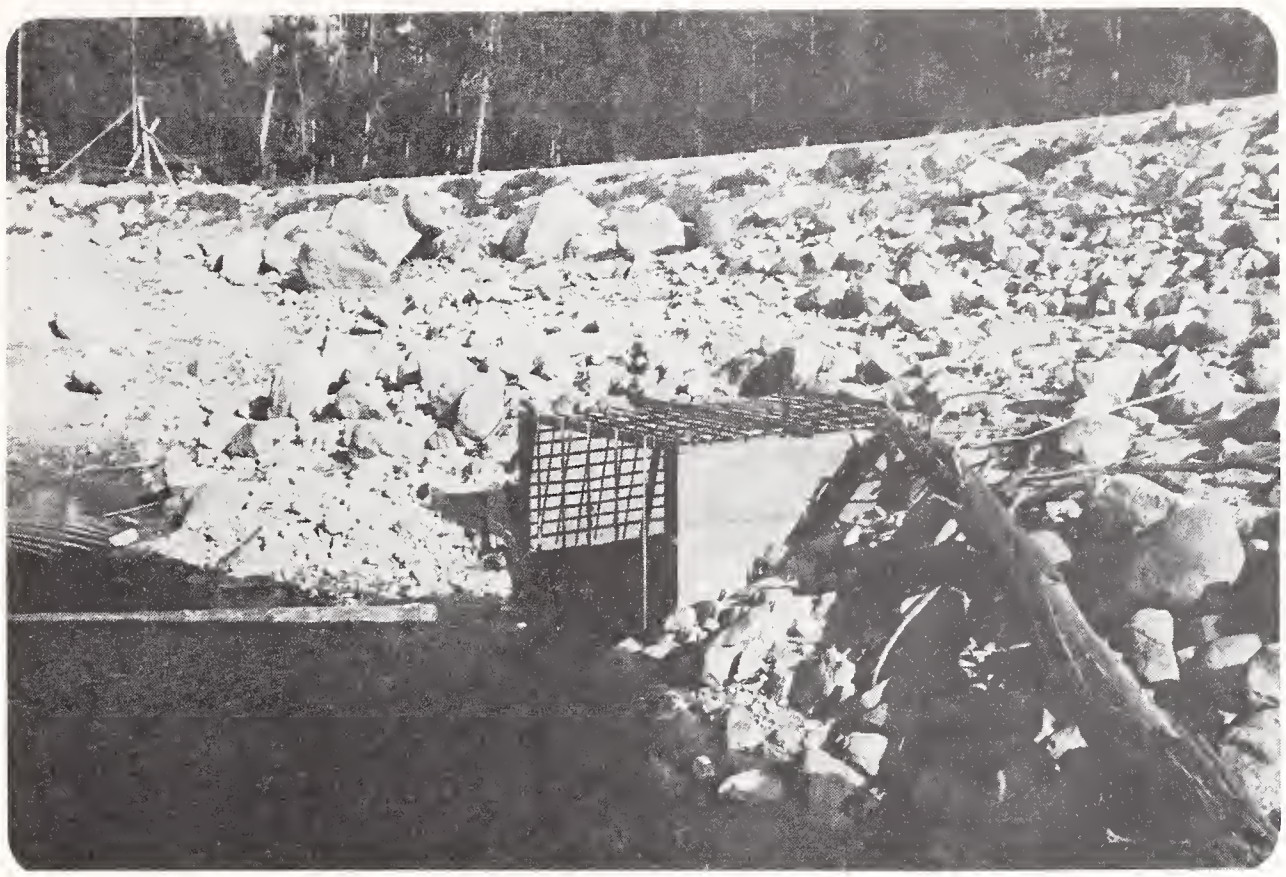
(PHOTO 9) Right Side of Spillway
Drop Structure



(PHOTO 10) Left Side of Spillway
Drop Structure

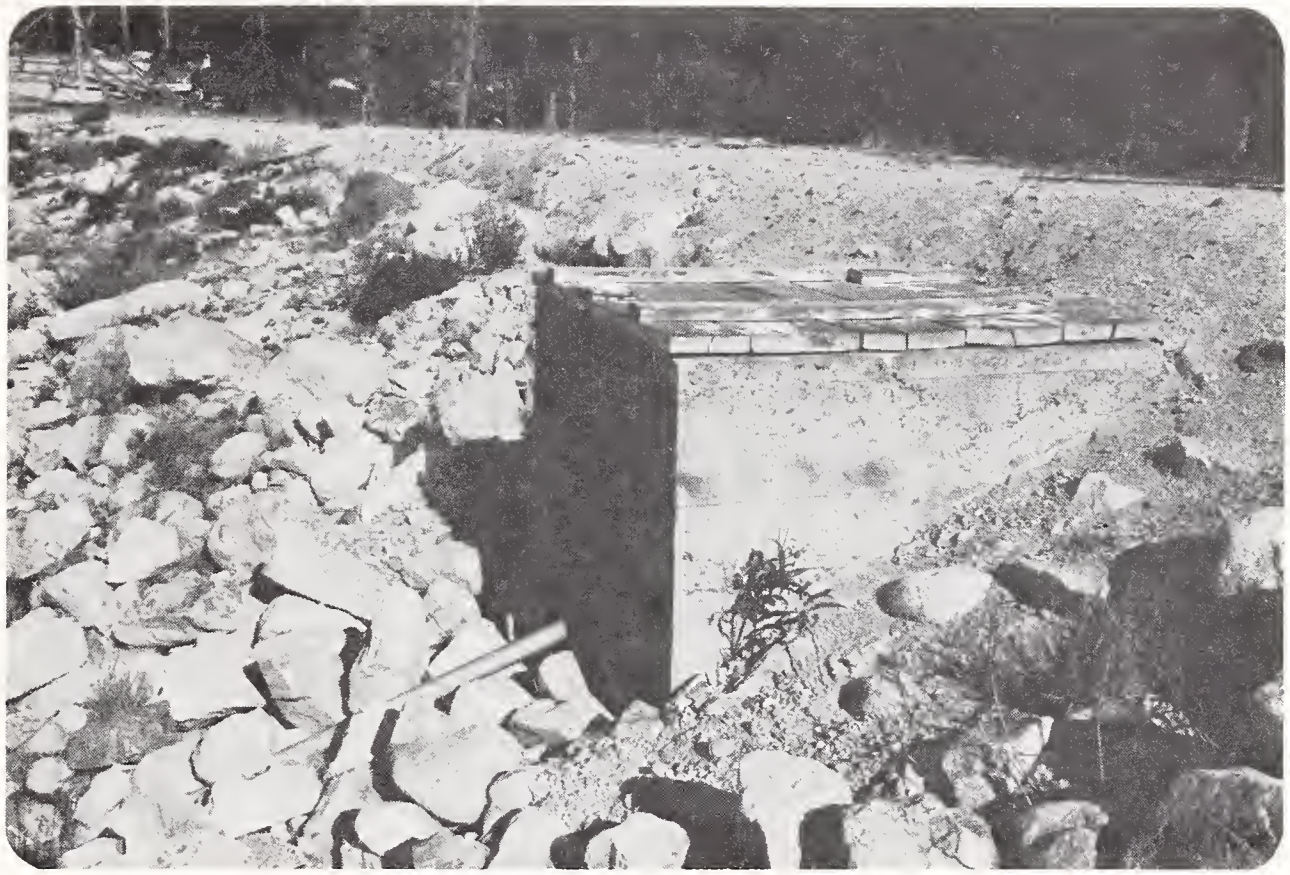
(PHOTO 11) Spillway Exit Channel,
Looking Upstream

(PHOTO 12) Spillway Exit Channel
from Drop Structure

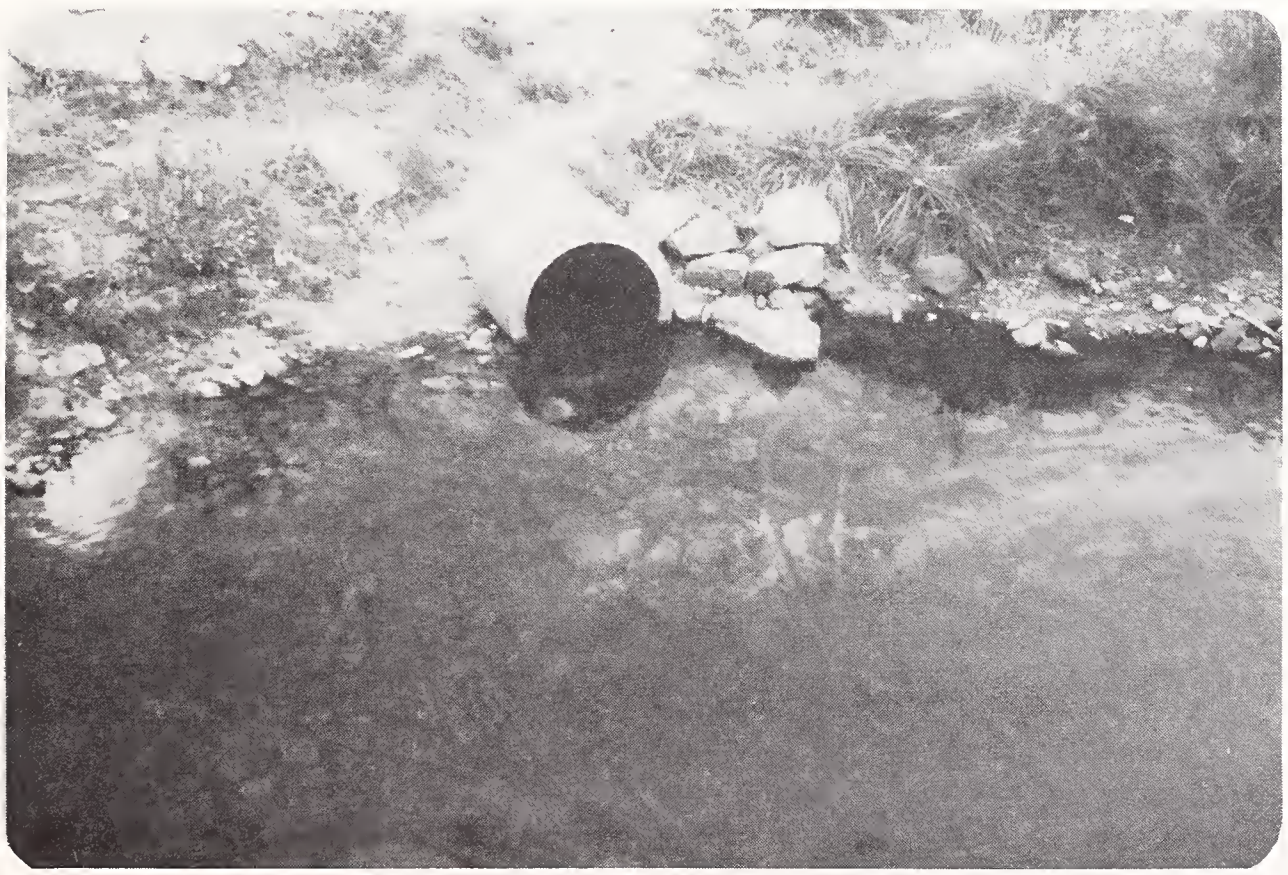


(PHOTO 13) Low-Level Inlet Structure and Trash Rack

(PHOTO 14) Inclined Slide Gate Controlling Low-Level Outlet

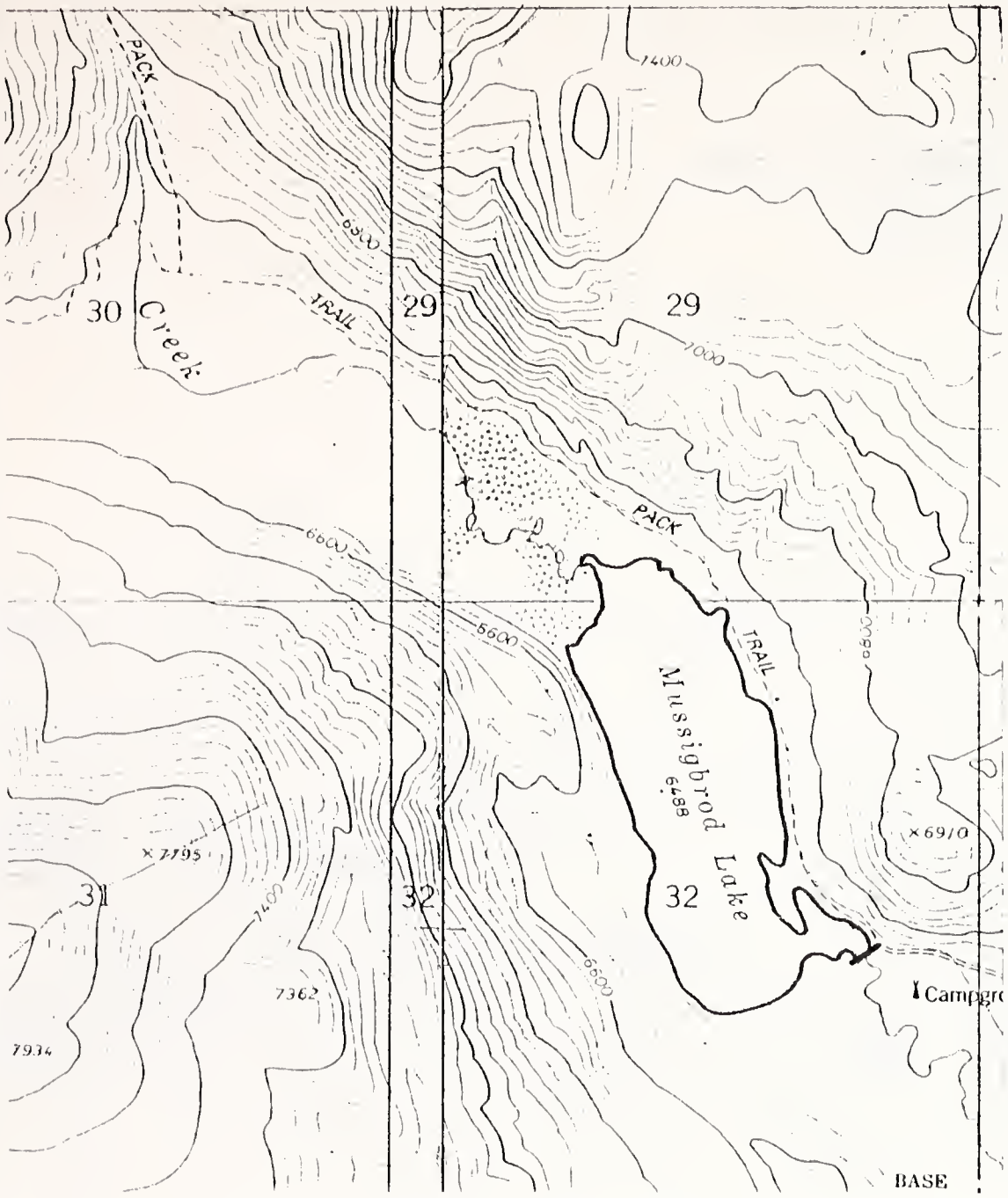


(PHOTO 15) Gate Control Box



(PHOTO 16) Conduit Outlet

(PHOTO 17) Looking Downstream from
Maximum Section

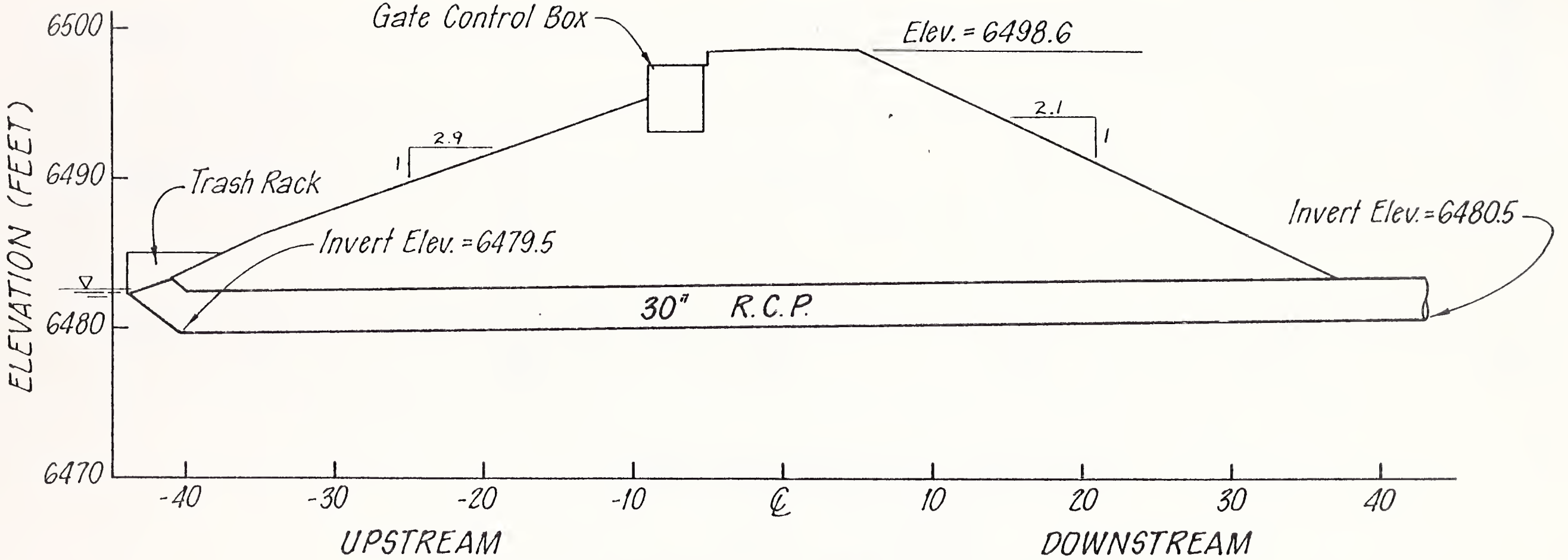


SITE PLAN

VICINITY MAP

PLATE 1
MUSSIGBROD LAKE & DAM
SITE PLAN & VICINITY MAP

MUSSIGBROD LAKE DAM
MONTANA

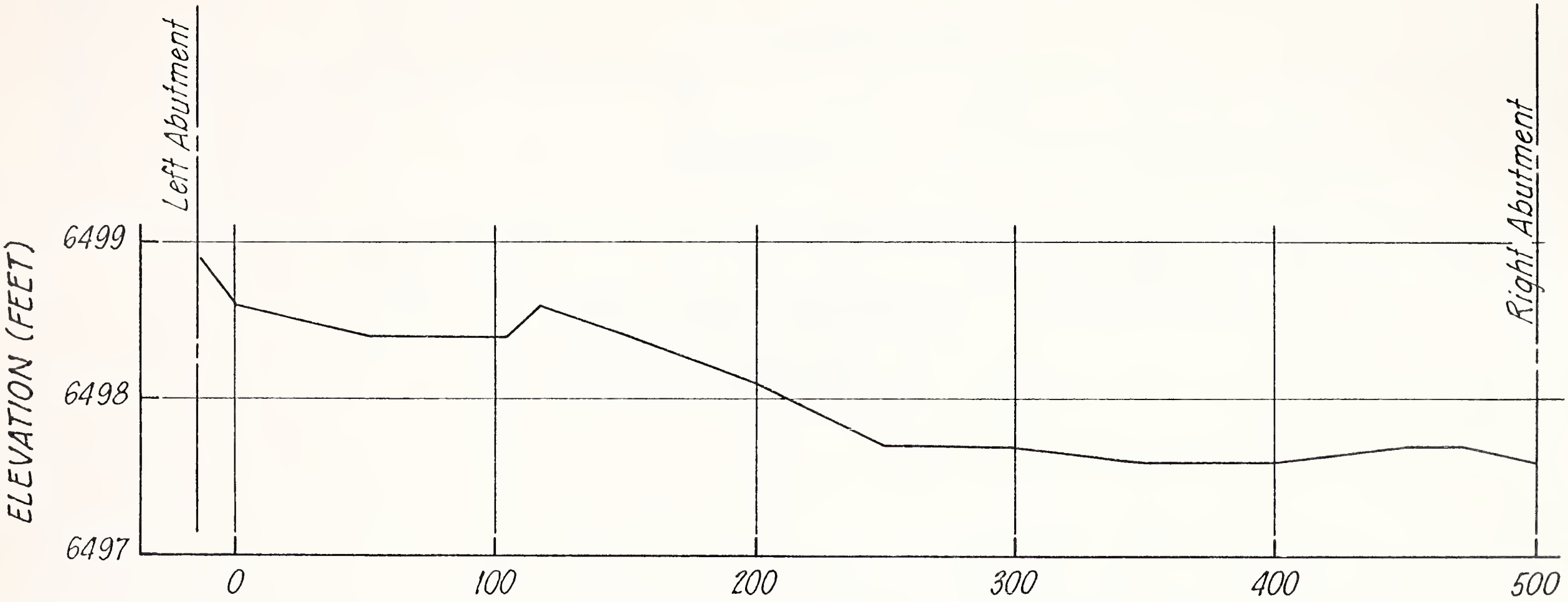


CROSS-SECTION OF DAM AT OUTLET

Scale: 1" = 10'

PLATE 2

MUSSIGBROD LAKE DAM
MONTANA

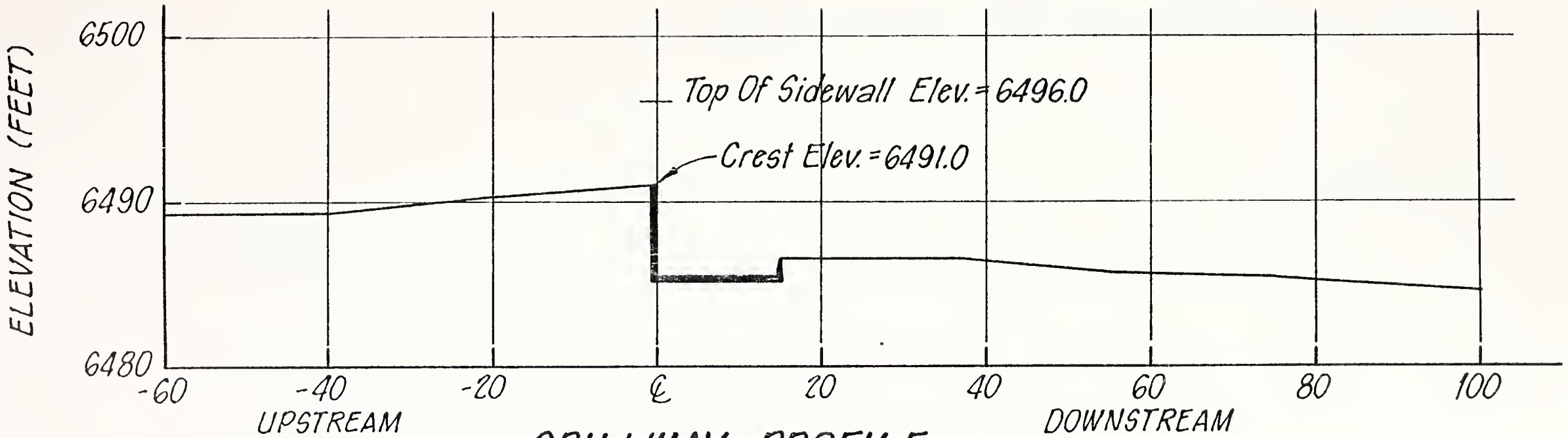


DAM CENTERLINE PROFILE

Scale: 1" = 60' Horiz.
1" = 1' Vert.

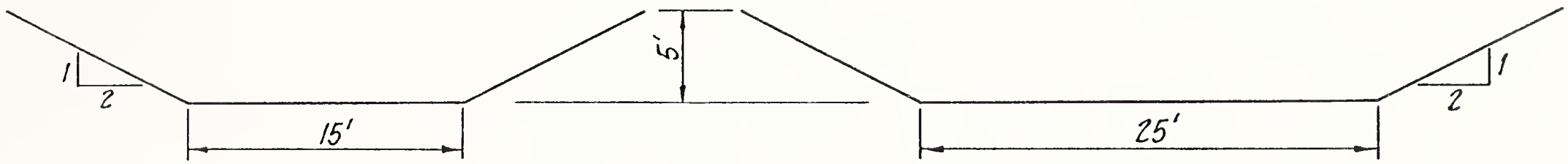
PLATE 3

MUSSIGBROD LAKE DAM
MONTANA



SPILLWAY PROFILE

Scale: 1" = 20' Horiz.
1" = 10' Vert.



35' DOWNSTREAM FROM CREST

15' DOWNSTREAM FROM CREST

TYPICAL SPILLWAY CROSS-SECTIONS

Scale: 1" = 10'

PLATE 4

ELEVATION - AREA & STORAGE CURVE
MUSSIGBROD LAKE
MONTANA

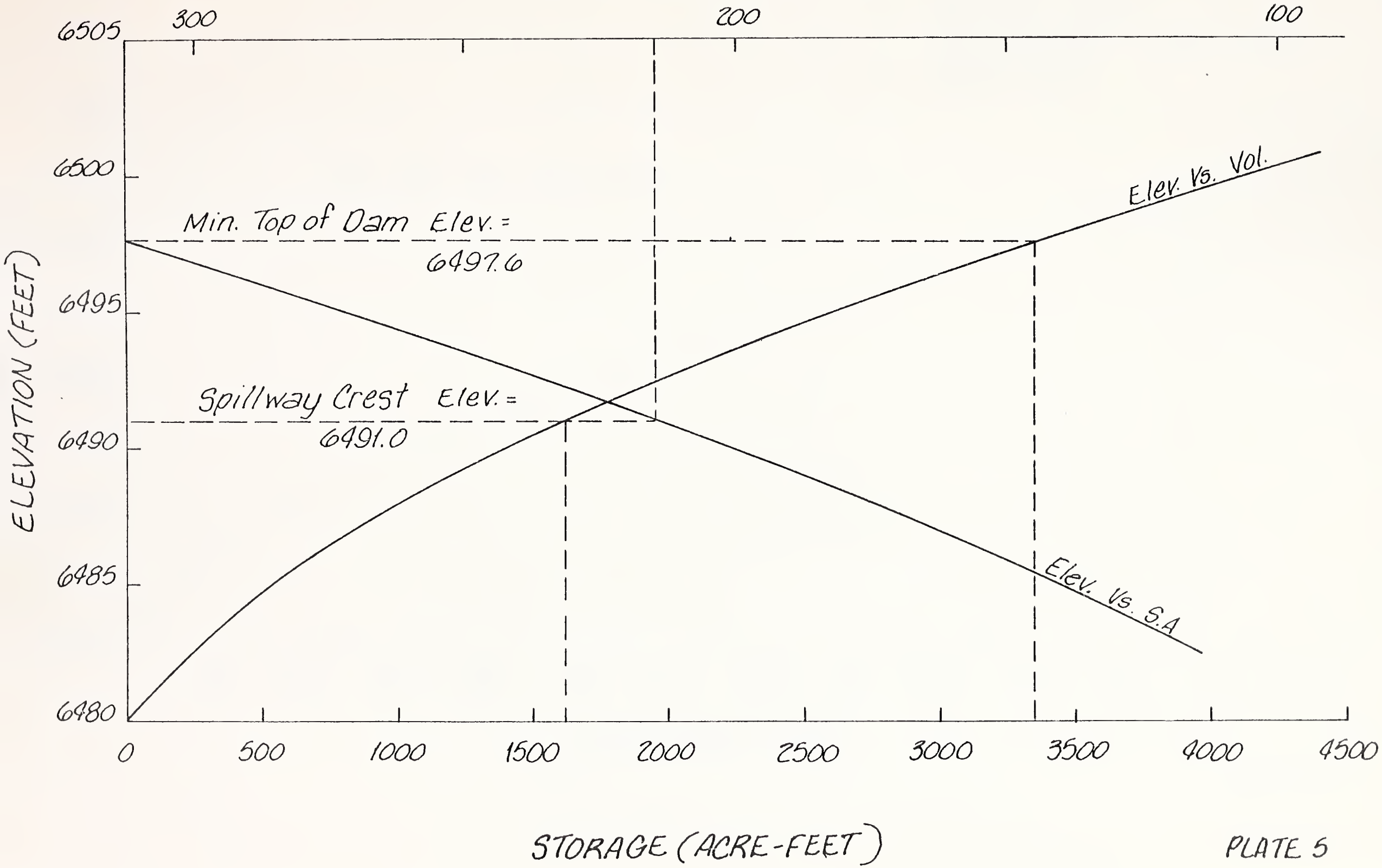


PLATE 5

SPILLWAY DISCHARGE RATING CURVE
MUSSIGBROD LAKE DAM
MONTANA

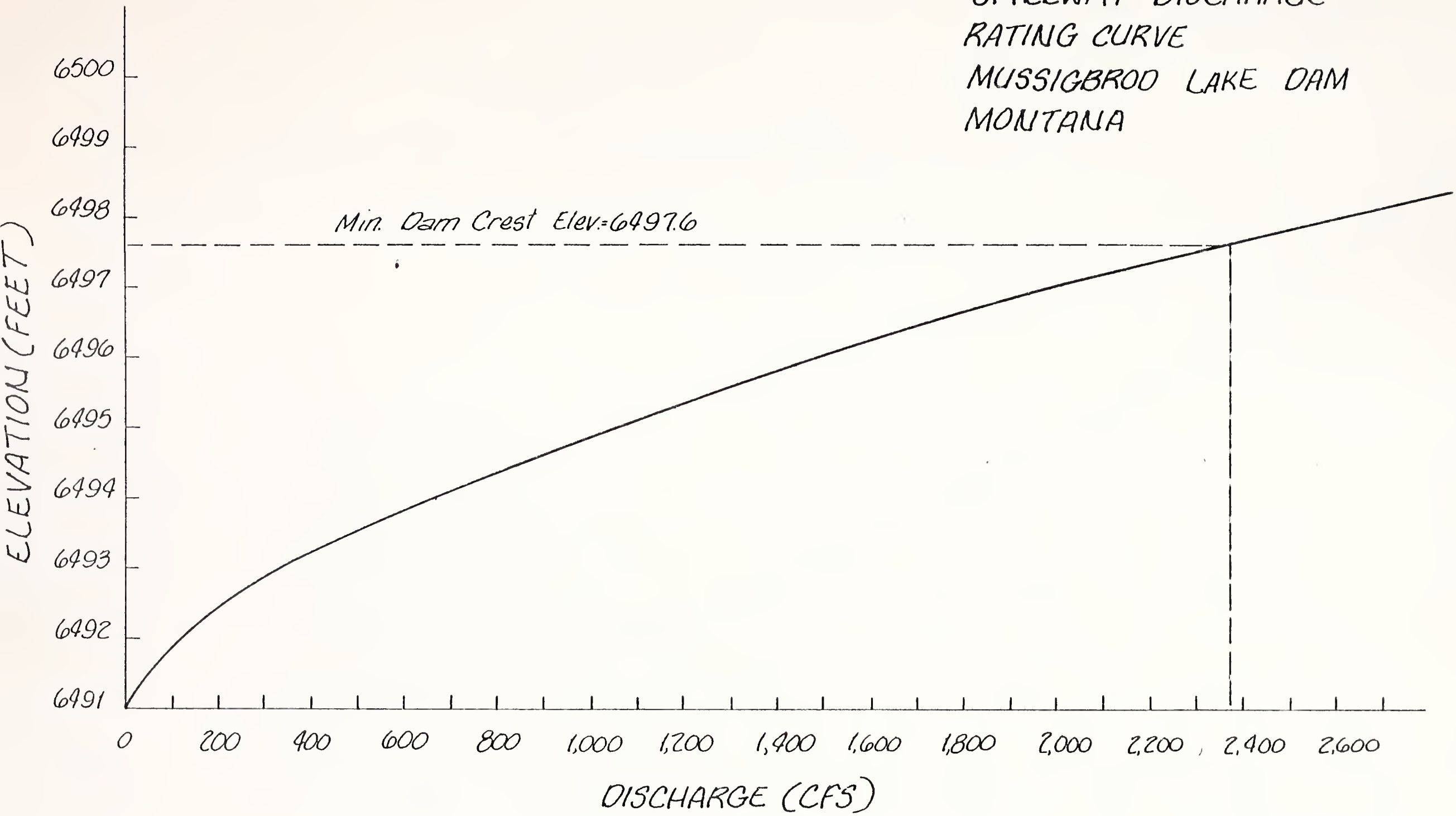


PLATE 6

30" RCP OUTLET
DISCHARGE RATING CURVE
MUSSIGBROD LAKE DAM
MONTANA

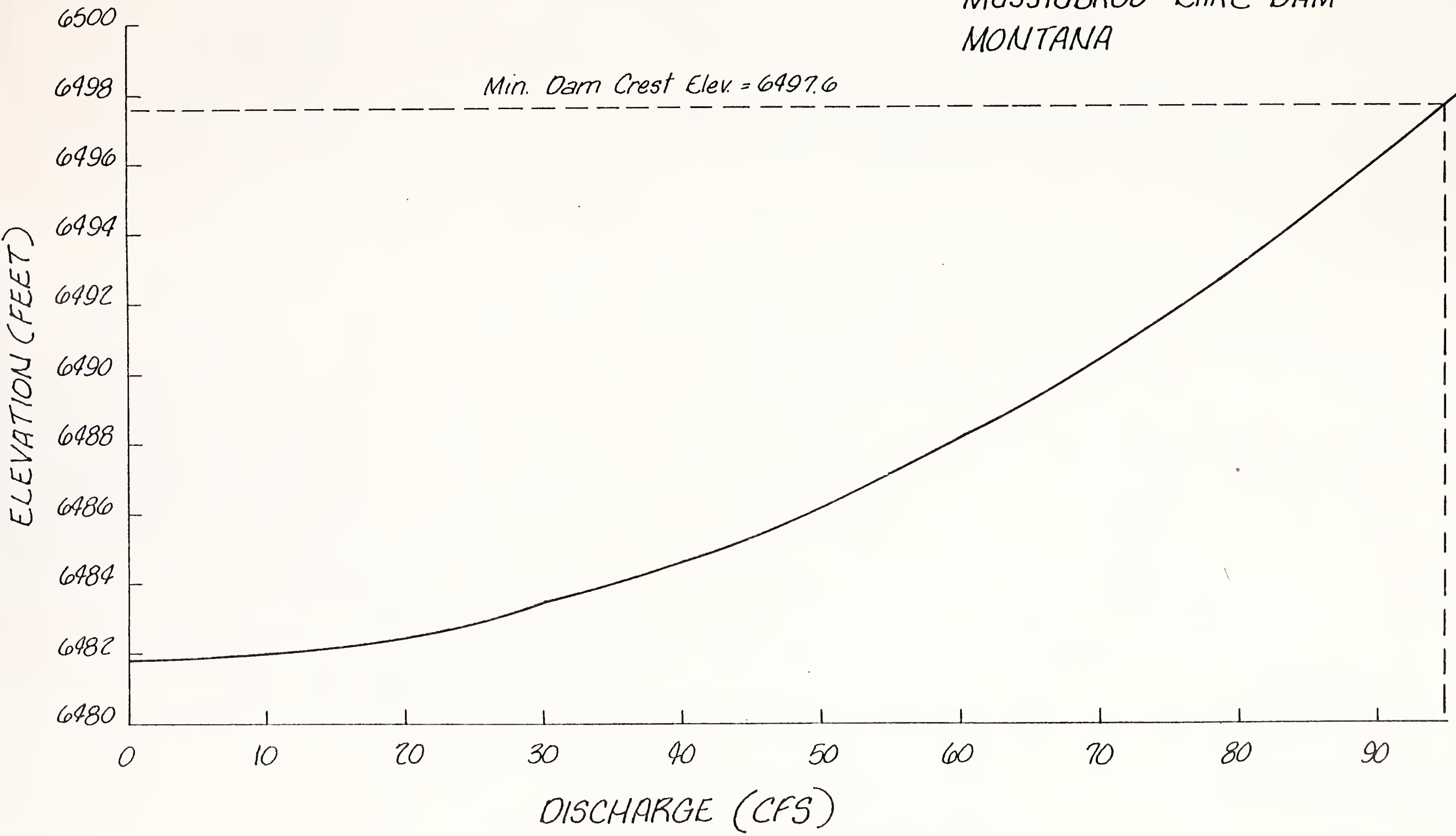
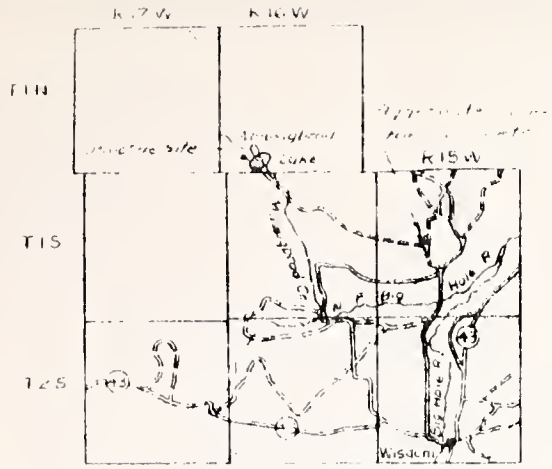


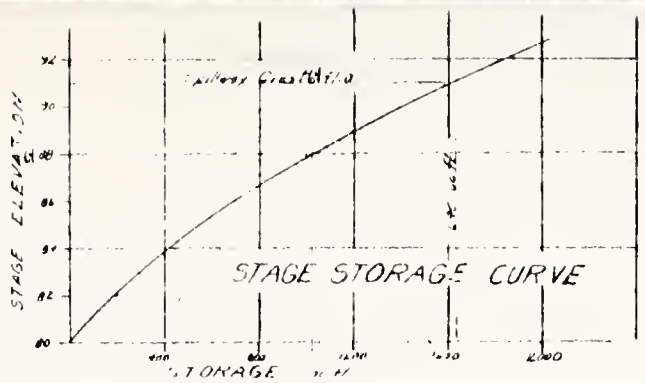
PLATE 7



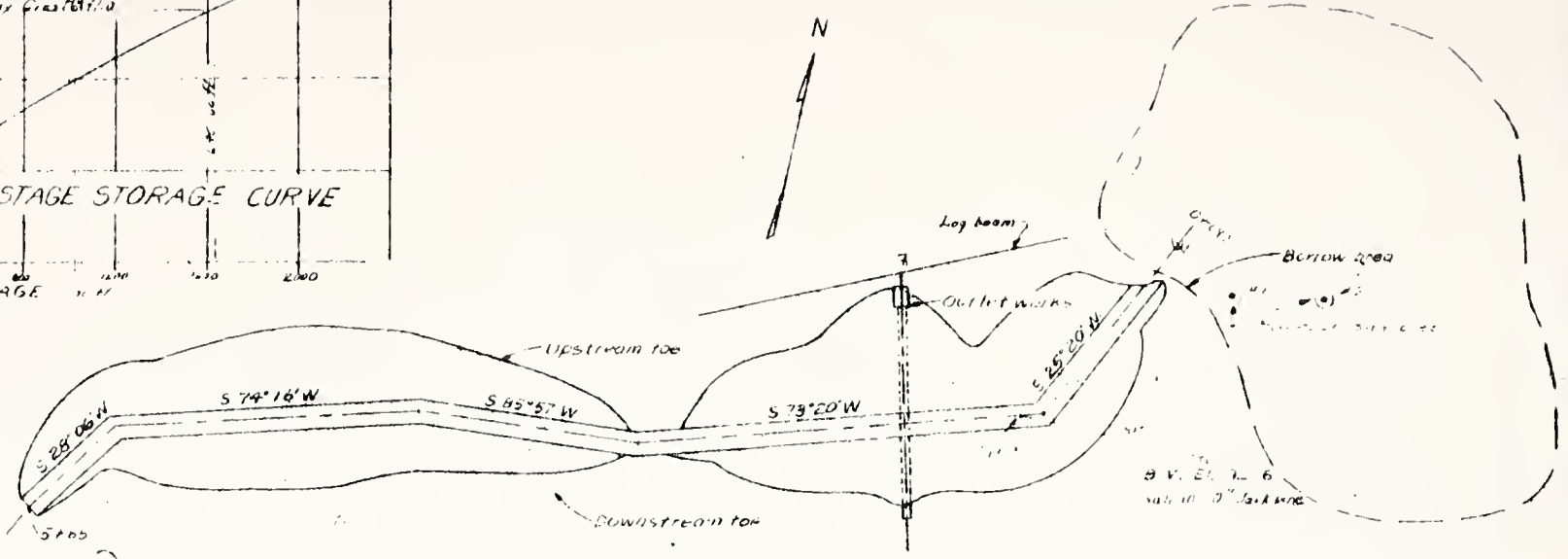
GENERAL LOCATION MAP

Scale 1"=2500'00

Drainage Area 15.2 sq. m.



STAGE STORAGE CURVE



GENERAL PLAN LAYOUT

Scale 1" = 40'

Existing channel (Existing debris to be piled and burned)
S 14° 40' W
S 14° 30' E
Dike
Spillway
Outlet
Existing structure
Excavate borrow pits to be pond type farmed, channels to be removed from channel graded to a uniform width and cross section.

1	[illegible]		2230
2	[illegible] dam. 1068 215 [illegible] E (4000 psi [illegible] 28 days)		1283
3	[illegible]		79.5
4	[illegible]		10,464
5	[illegible]		2
6	[illegible]		40
7	[illegible]		230
8	[illegible]		910
9	[illegible] "B"		24
10	[illegible] "B"		20
11	[illegible]		1
12	[illegible]		31
13	[illegible]		1
14	Air vent - [illegible]		[illegible]
15	Trash rack - Furnish & install per detail	LBS	1
16	Log Boom - Furnish & install per detail	LF	2
[illegible]	Excavation Spillway & Foundation Grading	CU YD	670

Forest service [illegible]

Approved [illegible] Regional Engineer, U.S.F.S.

PLATE 8

GENERAL PLAN LAYOUT

MUSSIGBROD DAM

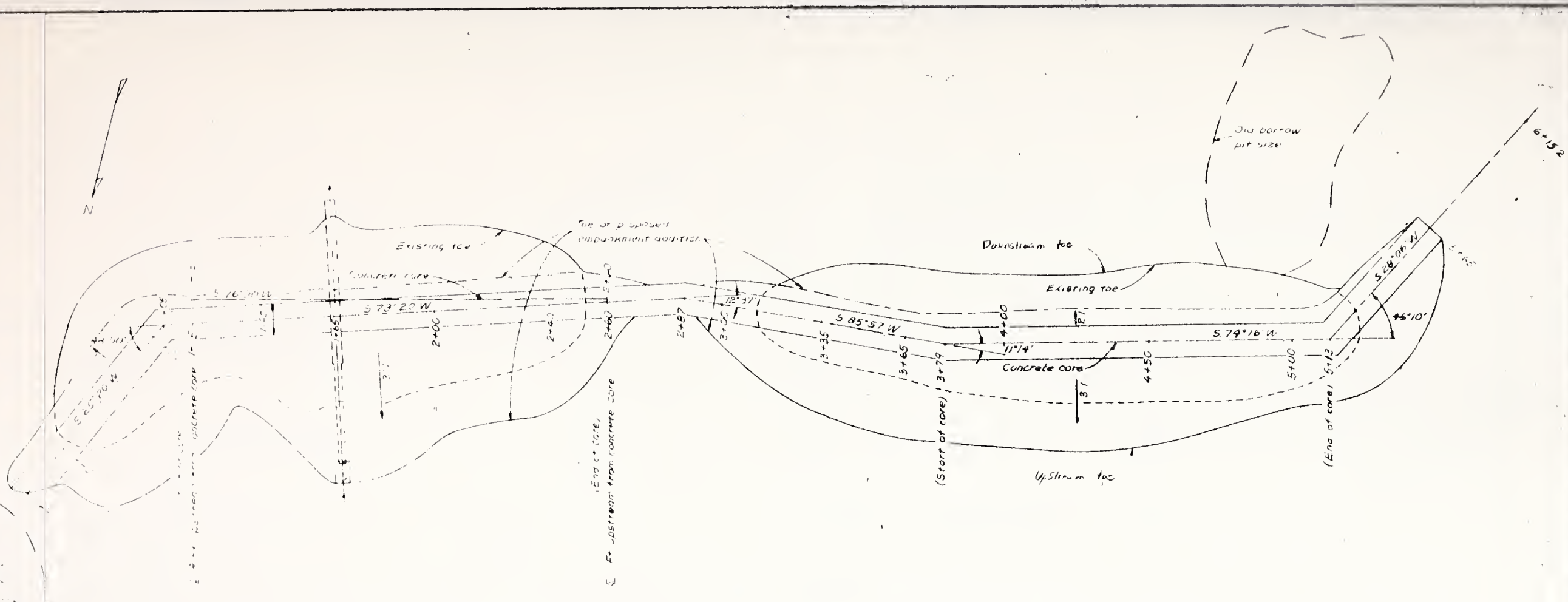
REHABILITATION

BEAVERHEAD NATIONAL FOREST, BEAVERHEAD CO.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	Approved by: E. L. [illegible]
Designed R S		Title
Drawn G K	9-66	
Traced M K	1-67	Title
Checked R S	9-66	Sheet No. 1 of 11 — Drawing No. MT. E-06-003

SCS-313 (9-64)


N
Old borrow pit site
Existing toe
Concrete core
Top of proposed dam
Downstream toe
Existing toe
Concrete core
Upstream toe
(Start of core)
(End of core)
(End of core)
S 73° 20' W.
S 85° 57' W.
S 79° 16' W.
S 28° 04' W.
46° 10'
11° 14'
12° 31'
2+00
2+40
2+60
2+87
3+35
3+65
3+79
4+00
4+50
5+00
5+13
6+52
PLAN
Top of proposed dam
Top of existing concrete core wall
Existing ground surface
Estimated original ground surface
Glacial moraine knoll
Estimated bottom of existing concrete core wall
Existing 48 inch R.C. irrigation outlet
ELEVATIONS
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+70
STATIONS
PROFILE ALONG ℄ OF DAM
Scale: 1" = 20' Horiz
1" = 5' Vert
REV 7-67
PLATE 9
PLAN LAYOUT AND PROFILE
MUSSIGBROD DAM
REHABILITATION
BEAVERHEAD NAT'L FOREST BEAVERHEAD CO.
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed RS 9-66
Drawn GK 9-66
Traced MK 1-67
Checked
Approved by
Title
Sheet No 2 of 11
Drawing No MT, E-06-093
SCS-313 (9-64)

NOTE Allow 5% overfill for shrinkage

Cover not shown

Gate hoist see detail

El 97.5

El 93.0

Existing embankment

Existing concrete core

Excavation limits

Existing secured core & pipe from core downstream to be removed

Joint block & anti-seep collar

Note: If existing concrete pipe has reverse slope (downstream end higher than the upstream end) the complete pipe will be removed and and reinstalled as directed by the engineer

Trash rack not shown See detail

Existing headwall & first section of pipe to be removed

Joint block & anti-seep collar

anti seep collar

30" dia R.C.P.

48" dia. R.C.P.

El 78.5

El 79.5

El 95.0

5" thick non-reinforced concrete bedding

Inlet structure see detail

16'-0

6'-0

40'-0

Existing concrete pipe to remain in place

Three 8'-0" lengths required

Two 8'-0" & one 8'-0" lengths required

8'-0

48" dia to 30" dia eccentric reducer

Pipe supports See detail

PROFILE ALONG ℄ OF OUTLET WORKS

Note: All pipe to be A.S.T.M. C76 Class III Wall B with O ring gaskets

DETAIL A

Scale 1" = 1'-0"

DETAIL B

Scale 1" = 1'-0"

DETAIL C

Scale 1" = 1'-0"

TRASH RACK DETAIL

Scale ½" = 1'-0"

IRRIGATION OUTLET HYDRAULIC DATA

$Q = CA\sqrt{2gH}$ $C = \frac{1}{\sqrt{\Sigma K}}$

HEAD LOSS COEFFICIENTS

Entrance	$K_e = 0.50$
Velocity	$K_v = 1.00$
Pipe friction	$K_f = 0.24$
Minor (bend & enlargement)	$K_m = 0.45$
	$\Sigma K = 2.19$

IRRIGATION OUTLET WORKS
STAGE DISCHARGE DATA
(Gate fully open)

ELEVATION	Q cfs
82.0	0.0
83.0	266
84.0	376
85	461
86.0	533
87.0	596
88	652
89.0	704
90	754
* 91.0	799
92	842
93	882
94.0	922
95.0	956

* Elevation at crest of emergency spillway

PLATE 10

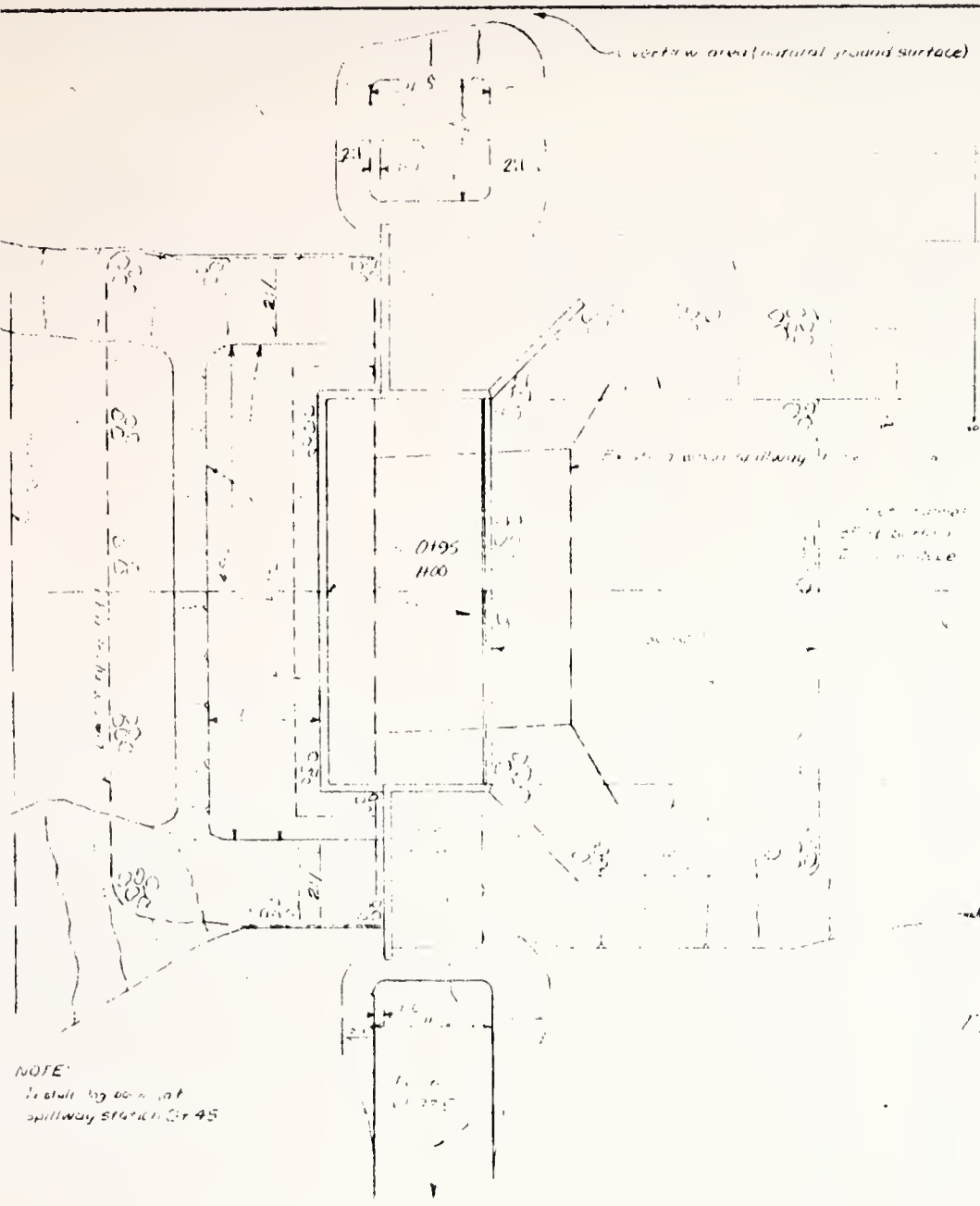
OUTLET & TRASH RACK DETAILS
MUSSIGBROD DAM
REHABILITATION
BEAVERHEAD NTL. FOREST BEAVERHEAD CO.

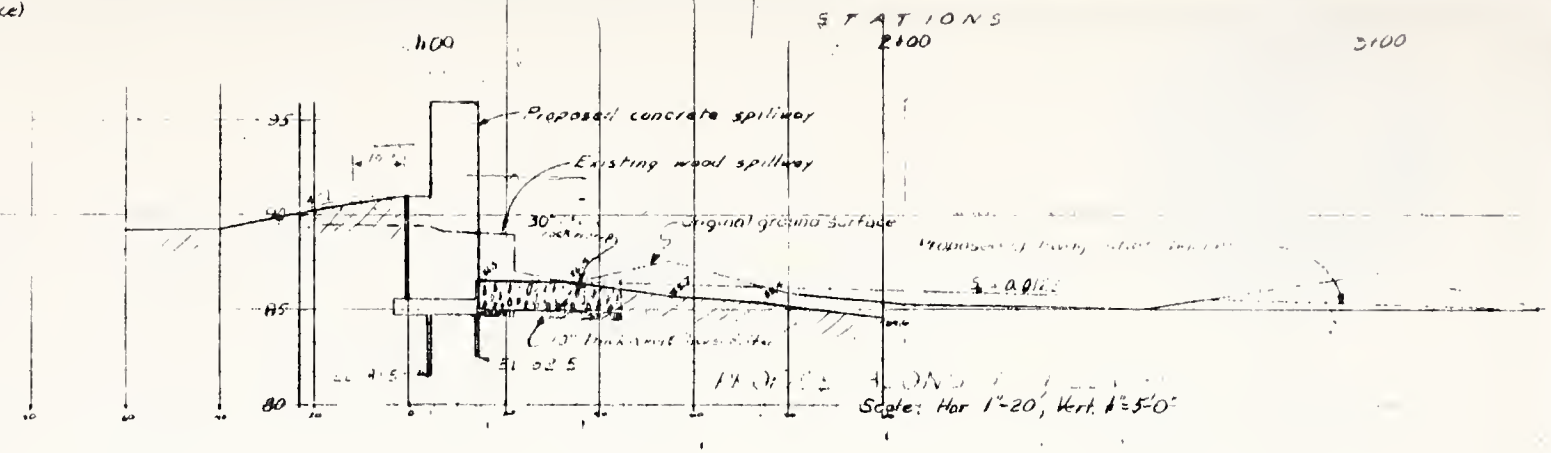
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

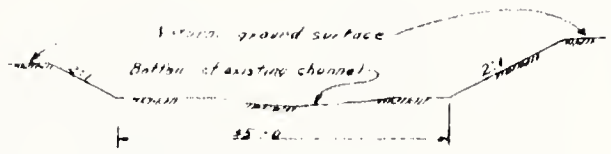
Designed	R. S.	Date 1-67	Approved by
Drawn	G. A. - 1/8" = 1'-0"		Title
Traced			Title
Checked	R.S.	4-67	Sheet No. of sht.

Drawing No. 117E-06093

SCS-313 (9-64)



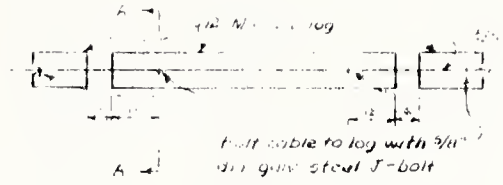




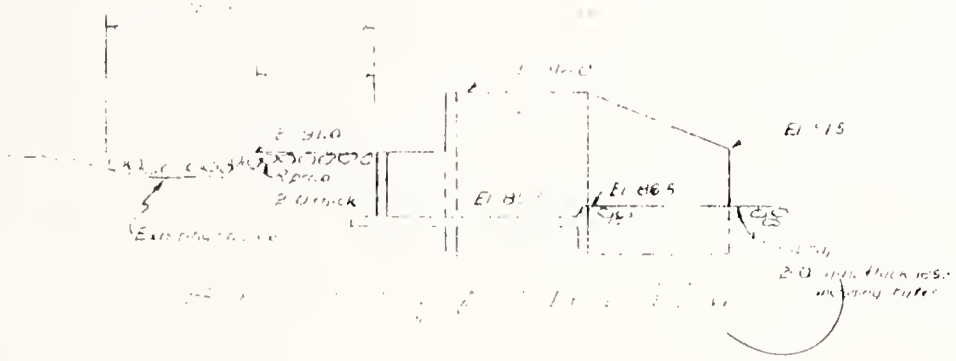
TYPICAL OUTLET CHANNEL CROSS SECTION
Scale: 1" = 10'-0"

ITEM			
1	[illegible] M (3000 psi compressive strength	cu.yd.	601
2	[illegible]		
3	[illegible]		
4	[illegible]		
5	[illegible]		
6	[illegible]		
7	[illegible]		
8	[illegible]		
9	[illegible]		

NOTE
1 [illegible]
2 [illegible]
3 [illegible]
4 [illegible]
5 [illegible]



LOG BOOM DETAIL
Not to scale



SPILLWAY HYDRAULIC DATA

Broad crested weir C=3.1
Length of crest L=45 ft

$Q = CLH^{\frac{3}{2}}$

SPILLWAY STAGE CAPACITY TABLE

STAGE ELEVATION	H	Q cfs
91.0	0.0	0
91.5	0.5	49
92.0	1.0	140
92.5	1.5	257
93.0	2.0	396
93.5	2.5	551
94.0	3.0	725
* 94.5	3.5	914
95.0	4.0	1117
95.5	4.5	1335
96.0	5.0	1568

* Design capacity

REV 1 67

PLATE 11

REMEDIAL PROFILE OF EMERGENCY SPILLWAY
MUSSIGROD L-4 W
REHABILITATION
BEAVERHEAD N.F. FOREST BEAVERHEAD CTY.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Date
Designed
Drawn
Traced
Checked MS
Approved by
Title
Scale
Drawing No. M-E 06.099

SCS 3-13 (9-64)

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU

HELENA, MONTANA 59620

February 27, 1981

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Ralph Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Inspection Report on Mussigbrod Lake Dam (MT-184)

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for the opportunity to review and comment on the final draft report on Mussigbrod Lake Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:AT:lj

"AN EQUAL OPPORTUNITY EMPLOYER"

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

FEB 17 1981

7530

Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

We have reviewed the draft report on the Phase I study of Mussigbrod Lake Dam and have the following comments:

We agree a more detailed hydrologic study is needed to better determine the hazard this dam presents and believe any expenditures of funds for further investigation would depend on the conclusions of such a study.

Sincerely,

Beryl Johnston

BERYL JOHNSTON
Acting Director
Engineering

cc: Beaverhead NF

United States Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, MT
59715

March 6, 1981

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft on Mussigbrod Lake Dam (MT-184).

Our comments relating to specific report statements are:

Page iii, paragraph 5: Recommend that these paragraphs give more emphasis for the need for more realistic and detailed study to support any project modifications.

Page 13, line 10, and page 22, line 16: It is not clear if the sag and misalignment are in the last downstream joint of pipe or further under the fill.

Plate 8 and 11. A crest profile along natural ground between the dam and the spillway was not given. Will the overflow areas shown on plates 8 and 11 act as emergency spillways and if so, what is their capacity?

Photo 15: Recommend that exposed portions of the control stem and vent pipe be covered to a depth of at least 2 feet with hand placed rock riprap as shown on the original plans. This is to prevent ice floe damage.

Page iii, paragraph 5 and page 24 item 6: Request these paragraphs give more emphasis to the need for a more detailed study to support any project modifications.

Page 23, item 4: There is no mention in the body of the report that a low-level inlet log boom is in disrepair.

Page ii, line 6 and page 5, line 2: We feel the downstream hazard is overstated. The Forest Service campground is a primitive camp that is not likely to be used during the early spring during frozen ground conditions. It would be much more reasonable to move the one or two low campsites rather than construct enormous spillways. The creek opens out onto a bench 2½ miles downstream, while the first and second inhabitable structures are 4 miles and 8 miles respectively downstream. The concrete core wall and the large fill rock are a deterrent to sudden failure during overtopping.

General Comments:

We do not feel the meteorologic and hydrologic conditions used to develop the PMF are realistic. The conditions and criteria selected attempt to eliminate

element of risk to a degree that is not reasonable or practical.

We request that the meteorologic and hydrologic assumptions and conditions be fully presented and justified in the report.

We urge that a breach flood routing and thus a substantiated hazard classification be made in the Phase I inspection. With such a brief field overview, general hydrologic modeling and a subjective hazard analysis, the report is forcing the as yet unjustified economic burden of a Phase II inspection on the dam owners.

Sincerely,

James L. Johnson

For Van K Haderlie
State Conservationist

cc:
Ray Smith, State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman